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ABSTRACT

This report summarizes a series of studies on the ability to structure acoustic material as a measure of musical aptitude. It is divided into two sections. Section one explains the general approach of the study. Behavioralism as a research approach which rejects inner states of being in favor of studying concrete operations, the importance of constructs (theories about what has caused observed facts), and psychological properties and processes as objects of study are discussed. The section also examines the concept of spatial ability as relevant to musicality research. Section two discusses results of the research. Three major questions are raised: Does the acoustic structuring test really measure acoustic structuring ability? Is acoustic structuring ability connected to musical behavior closely enough to be called musical aptitude? How is acoustic material structured? The author notes that factors such as sensory capacity and rote memory may interfere with the validity of the test, but on the whole, persons who cannot perceive structures are likely to score lower. The ambiguity of the term "musical aptitude" is noted and the author stresses that it is difficult to get direct correlations between the structuring test and musical aptitude. However, the empirical evidence does not make this hypothesis unreasonable. Finally, the problem of structuring lies in the transformation rules between process (the act of reproducing, recalling, or encoding) and structure (a piece of music in a static state). (Author/KC)

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Kai Karma

THE ABILITY TO STRUCTURE ACOUSTIC MATERIAL AS A MEASURE OF MUSICAL APTITUDE

5. Summary and Conclusions

Academic dissertation to be publicly discussed, by permission of the Faculty of Education, in the University of Helsinki, in lecture room III, Porthania, on May 23, 1980, at 12 o'clock noon

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Helsinki 1980

Karma, Kai: The Ability to Structure Acoustic Material as a Measure of Musical Aptitude. 5. Summary and conclusions. Research Bulletin N:o 52, Institute of Education, University of Helsinki. 1980. 33 pp

The raport is the summary of a series of studies published under the general title "The Ability to Structure Acoustic Material as a Measure of Musical Aptitude". The general approach used in the series of studies as well as the results and their interpretation are handled in the summary.

First, the role of hypothetical constructs in research is briefly described. Research tradition is divided into two lines, one which avoids the use of constructs (behaviorism, operationism) and the other which uses them as central tools. The present study is associated with the latter because its main objective is to investigate the nature of musical aptitude, which is seen as a hypothetical construct.

The initial hypothesis about the nature of musical aptitude was that it is analogous to spatial ability to a great degree. The empirical measures of musical aptitude have been obtained with an acoustic structuring test developed for the present study. The results are discussed in three parts:

1. Does the acoustic structuring test really measure acoustic structuring ability?
2. Is acoustic structuring ability so clearly connected to musical behavior that it is reasonable to call it musical aptitude?
3. How is acoustic material structured?

1. Part of the first question must be answered in terms of content validity: the test has been constructed so that rote memory and sensory capacities affect the results as little as possible. The empirical evidence has been obtained with a series of regression analyses which support the view that the test measures acoustic structuring ability.

2. The second problem is only partly empirical: it is the researcher´s task to decide which is the sufficient level of correlation between musical behavior and test scores. This problem area needs further study, but it is the writer´s opinion that if one wants to call the acoustic structuring ability "musical aptitude", the empirical evidence does not make it unreasonable.

3. Only a couple of preliminary answers to the third question can be given on the basis of the present study. It seems that both verbal and spatial abilities may correlate with acoustic structuring. These correlations vary with the subject groups tested; a possible explanation to this is the amount of training and experience in music the subjects have.

Preface

The present study has been made at the Institute of Education, University of Helsinki, and has lasted over six years. During that time, Professor Eelis Aurola, Professor Johannes Alikoski and, for the most time, Professor Erkki A Niskanen, have worked as heads of the institute. I wish to thank them for a positive and encouraging attitude towards the research and the possibility to publish the results in the Research Bulletin series of the institute.

The whole staff of the institute has its part in creating the atmosphere of the institute and in providing ideas and comments often valuable for one's study. Especially, I want to thank Associate Professor Erkki Komulainen· without his competence in research methodology, as well as his ADP-programs and willigness to help, it would be much more difficult to make research at the institute.

A great deal of the material handled in the study was collected while I was working for the DPA-project led by Professor Koskenniemi and financed by the Academy of Finland. The co-operation of the DPA-team was indispensable in this phase of my research

A grant from the Finnish Cultural Foundation made it possible to analyze part of the material and make some test tapes.

Co-operation with music institutes has made it possible to use relatively large sample sizes and

to obtain valuable information about the validity of the acoustic structuring test. I express my sincerest thanks to the principals of the institutes, Risto Saari, Olli Ruottinen and, especially, Erkki Pohjola and Timo Veijola.

Mr. Tor Kronlund and Mr. Peter Glithero have helped in improving my English, for which I am grateful.

Research of this kind would, naturally, be impossible without subjects who are willing to take the tests. I thank all the teachers and their pupils who have been involved in the study.

Helsinki, March 1980

Kai Karma

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1. The general approach

1.1. Constructs as the main objects of interest

One way of classifying scientific effort is to describe how practical vs theoretical its aims are. It is possible to find valuable and useful relations between phenomena without any knowledge about the nature of the relationships, i.e. without using a theory. For instance, one can predict very exactly how fast an object will fall in given conditions without having the slightest idea about what makes it fall. The rule may be extracted from a vast amount of observations; the resulting "law of nature" may have immediate practical use.

Within the behavioral sciences this would mean finding the relation between certain kind of input (stimulus) and output (response) without paying attention to the inner states of the organism which work as intervening variables in the research paradigm. In the history of psychology there are researchers, such as Watson and Skinner, who have not wanted to use inner states as explainers at all. This reluctance has been grounded on at least two factors. First, careless use of inner states leads easily to total subjectivism where the testability of the ideas becomes increasingly difficult or even impossible. By investigating behavior only, without supposing any internal states of the organism, one can maintain a relatively high level of objectivity and exactness; this can be thought to raise the scientific status of the research. Second, radical behaviorists and strict neobehaviorists try to show that concepts describing the organism are

not needed (Tuomela 1975, 481). Skinner (1953, 35) puts this in the following way: "The objection to inner states is not that they do not exist, but that they are not relevant in a functional analysis. We cannot account for the behavior of any system while staying wholly inside it; eventually we must turn to forces operating from without. Unless there is a weak spot in our causal chain so that the second link is not lawfully determined by the first, or the third by the second, the first and the third links must be lawfully related. If we must always go back beyond the second link for prediction and control, we may avoid many tiresome and exhausting digressions by examining the third link as a function of the first. Valid information about the second link may throw light upon this relationship but can in no way alter it".

The school of thought which rejects the inner states of the organism and studies concrete operations alone is often called operationism (for instance Hempel 1975, 94 - 106, de Groot 1969, 37, 253, 255). When the inner states are rejected concepts become synonymous with the corresponding series of operations.

The more theoretically oriented researcher sees the concrete operations as more or less secondary, not as the real end of study, but as a means of gaining knowledge about the reality "behind" the concrete and observable. A parallel between a scientific problem and a clock which cannot be opened, has been drawn: to get information about its mechanism one can listen at its ticking, shake it, test it with radiation and magnetism and so on. It is possible to get the correct idea about the mechanism but basically it remains hypothetical. The factors acting behind the directly observable phenomena are analogous to this mechanism. These are usually called hypothetical constructs or, simply, constructs

(de Groot 1969, 37 - 38, 65, Kerlinger 1973, 28, 432, Nunnally 1969, 85).

Constructs are deliberately invented to explain the observed reality and to give it coherence. Essentially, constructs are guesses about what has caused the observed facts. They are in use both in the natural sciences and the behavioral sciences although they are more frequent in the latter. Sometimes constructs are very abstract and hypothetical in the earlier phases of a dicipline but become encreasingly concrete when additional information is collected and the research methods become more sophisticated. This has happened, for instance, to the concepts "atom" and "gene". The constructs used within the behavioral sciences are usually at the abstract and hypothetical end of the continuum although theories about their closer nature are being developed and tested.

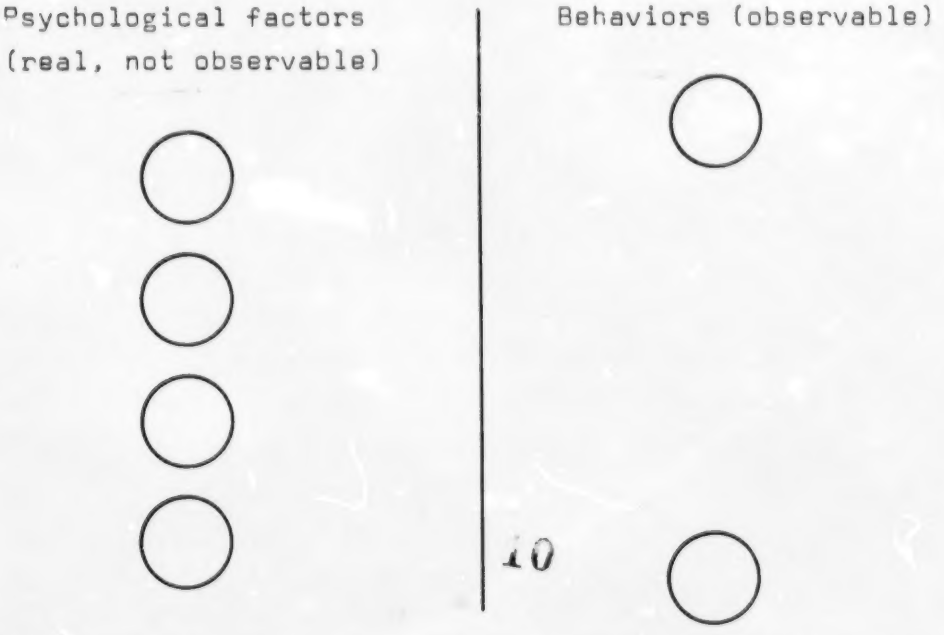
Constructs are the inescapable tools of theoretically oriented research. Developing constructs which explain the observable facts as completely as possible can be seen as the essence of research of this kind. In practice, the researcher studies the effects of the unknown, inner reality, makes hypotheses about what has caused the empirical findings, predicts new observable facts according to the hypotheses, tests these empirically and so on. Ideally, there ought to be a continuous interaction between theory and empirical study.

It is important to note that a good construct may be useful even if it describes only some of the properties of the phenomenon in question. The force of gravity, for instance, is a very useful construct although its closer nature is unknown. Basically, it is just a hypothetical force which attracts any material objects with an intensity related to the masses and distances of the objects. This abstraction tied together seemingly very different phenomena, such as

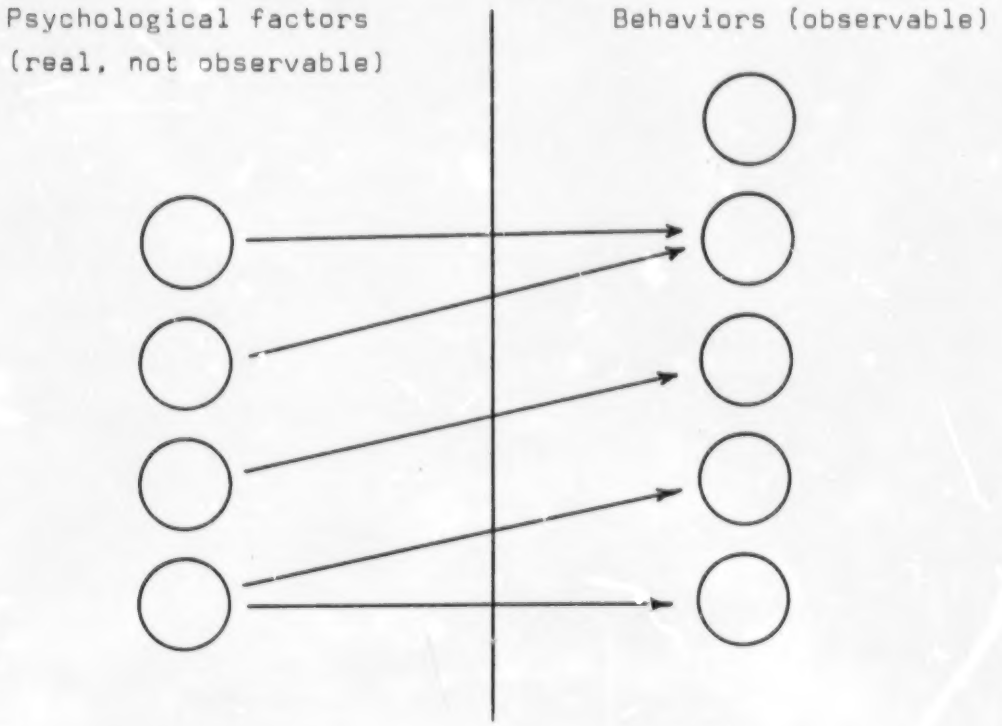
tides in the oceans and the orbiting of planets, and made the prediction of these phenomena more effective.

Within the behavioral sciences, constructs are psychological properties, such as needs, intelligence and personality factors, attitudes and so on. Their relations to theoretically oriented research may be clarified with the following series of figures:

The first figure describes the situation at a given moment, for instance when the subject comes to a testing situation. The researcher is interested in certain psychological properties of the subject's mind. These properties have developed within the frame formed by the innate capabilities of the individual and have been more or less affected by environmental factors. As long as the subject does not use the abilities in question, there is no possibility to gain information about them. In other words, the individual must behave in a relevant way if the psychological factors are to be investigated. For simplicity, the possible relations between the psychological factors have not been drawn:



The researcher collects data from the subject's concrete, observable behavior. These may be responses to tests, observations, interview material etc. The behavior has been affected by the psychological factors of the individual in question:

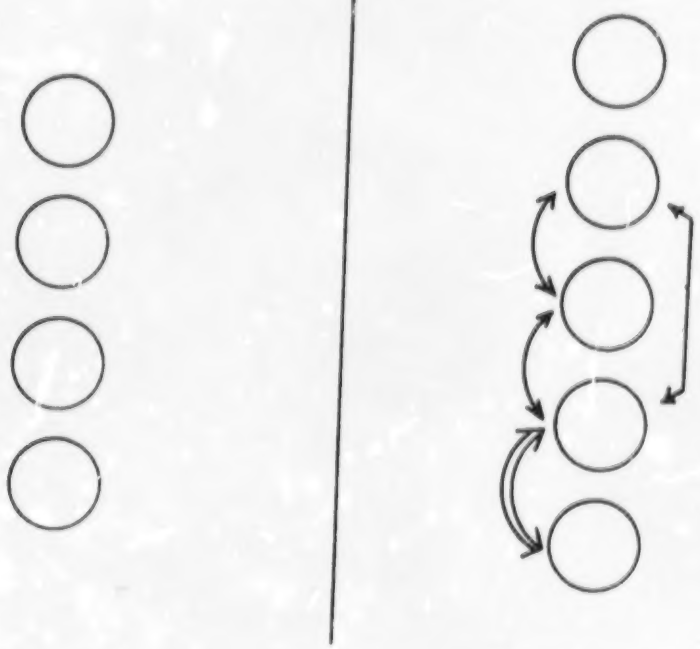


Very probably the observable behaviors are not in a one-to-one relationship with the psychological factors. Some psychological factors affect several behaviors, some behaviors must be affected by several psychological factors to be possible. Some behaviors are not at all affected by those parts of the subject's mind relevant to the study.

The influence the psychological factors have on the observable behavior forms a set of relations between the elements of behavior. This can be studied within an individual, but usually several individuals are used to study these relations.

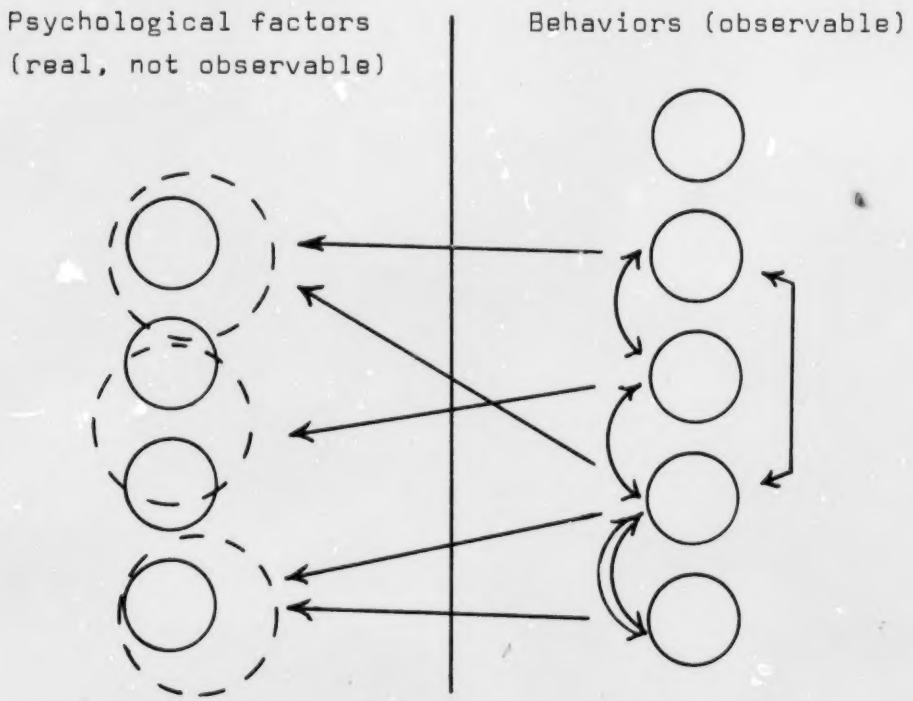
Psychological factors
(real, not observable)

Behaviors (observable)



The set of relations between the observable behaviors forms a basis for estimating the quality of the non observable, psychological factors. These estimates are constructs.

The constructs serve also as a basis for developing new measures; the cycle begins again when these are taken into use.



= construct, estimate of a psychological factor

The approach described above as theoretically oriented research forms the ideal which has been set for the present study. In other words, psychological properties and processes are the objects of study; behavior is studied because it is the only bridge to these. The theoretical approach was chosen because theory-building in the area is vague and gives unsatisfactory ground for practical measures, such as test construction. It seems that improvements in theory could lead to improvements in education and measurement with less trial and error than before.

This approach has some important consequences. Tests must be developed for effective validation of theory rather than for practical usefulness. This in turn means that when a reasonable degree of reliability has been attained, construct validity becomes the main concern; the reliability does not have to be as high as in individual prediction. Also, to keep the results clear and interpretable, a homogenous test should be preferred to a heterogenous one, although for practical prediction the latter may be more effective.

Theoretical approach also means that concepts become important not only as means of communication but as elements of an image of reality. If this view is adopted, the choice of what is included into a concept becomes very important. The criterion should not be an external, "practical" one (such as: "the abilities needed in music-making"), but rather information about internal, psychological, similarity of the behaviors or abilities in question (such as "they tend to be present together or not to be present together", i.e. they correlate).

1.2. Spatial ability as an analogy

The concept "spatial ability" is not used very consistently in literature. Earlier definitions, such as those suggested by Thurstone's studies seem to deal with relatively broad form relationships (Cronbach 1966, 256, 276 - 281). Both more detailed and more general definitions have been suggested, however. By factor-analyzing data from figural tests this general area can be split into several subclasses. Guilford and Hoepfner (1971, 116) name the following factors: Cognition of Figural Units, Cognition of Figural Classes, Cognition of Figural Relations, Cognition of Figural Systems, Cognition of Figural Transformations, Cognition of Figural Implications, Convergent Production of Figural Transformations, and Convergent Production of Figural Implications.

Smith, on the other hand, has suggested a broader definition: "There are indications, however, that the factor is not confined to the visual perception of shapes or patterns, but may be involved in perception in other modalities such as touch or hearing or in the perception of configurations in numerical or mathematical symbolism ... If subsequent research should confirm that tests such as abstractions, number series and arithmetic reasoning do genuinely involve a substantial amount of k, it will be necessary to extend our conception of the spatial factor to embrace abilities to perceive and recognize patterns which cannot be considered to be spatial or geometrical in any sense. The factor might still be appropriately described as a 'form perception' factor where the word 'form' is interpreted in the wider or more general sense in which it is used by gestalt psychologists. It may well turn out that 'form perception' is a more appropriate descriptive term for these tests than 'spatial'". Smith also mentions that the possible existence of an "auditory k-factor" (k-factor being similar to the broad spatial factor) has been mentioned in a congress of psychology as early as 1948. (Smith 1964, 210, 213)

Cattell calls the broad, visual form-perception factor 'visualization' instead of 'spatial ability': "Visualization ... is a broad, higher-order, 'provincial' factor, i.e., broader than a primary. Visualization extends to a broad array of performances, such as 'seeing' what will happen to a piece of paper when cuts are made in a folded state ... imagining the change of view when an object is rotated ... envisaging the direction of movement in one part of a machine when another part moves." (Cattell 1971, 34)

When the concept spatial ability is used in the present series of studies (Karma 1973, 1975, 1976, 1978) it refers to a relatively broad, visual form-perception factor. It has been operationalized by the mirror-test (identifying mirror-images and rotated figures), square completion

(choosing the correct pieces which complete a figure into a perfect square), and perception speed-test (checking figures similar to model figures) from Heinonen´s factor test battery (Heinonen 1963). For practical reasons, all three have not always been used together, but factor analyses show that they load clearly and similarly on the same factor (Karma 1978, ?).

In spite of the variance in the definitions of and tests for spatial ability, it seems that some properties relevant to the present study are usually implicit:

- Spatial ability must be clearly differentiated from sensory acuity, i.e. the ability to see details and absolute qualities of the stimuli. For instance, the difference is clearly elucidated in cases of brain injury, where the ability to perceive configurations or gestalten may be seriously impaired, while the ability to see the elements in detail is intact (Smith 1964, 182).

- The essential element in spatial ability is the use of relations instead of absolute qualities.

- Spatial ability is thought to be a relatively primary ability which is not much affected by training and culture (e.g. Smith 1964, 124). However, its presence makes the development of cultural applications easier. For instance, it is easier to develop a good technical or mechanical ability if one has a good spatial ability.

Consequently, tests designed to measure the primary spatial ability (i.e. not its applications) are abstract, such as hidden figures, completing basic geometrical figures, mirror-images, block designs and so on. If real objects or pictures of them are used as stimuli, they are usually simple and familiar to anybody, such as hands or flags.

One of the basic thoughts in the present work is that concepts and tests of this kind seem to be lacking in the area of musicality research. By transferring the above-mentioned principles of spatial tests into the auditive area, one might be able to combine the benefits of both "sensory" and "musical" types of measures. Mainly this would mean the possibility of keeping the measures objective and relatively culture-free without making them atomistic.

2. Results

It is easier to handle the results of the studies if the problem area is divided into three parts:

1. Does the acoustic structuring test really measure acoustic structuring ability?
2. Is acoustic structuring ability so clearly connected to musical behavior that it is reasonable to call it musical aptitude?
3. How is acoustic material structured?

It is obvious that the first question must be answered first; if the answer is negative the two other questions are premature.

2.1. Does the acoustic structuring test really measure acoustic structuring ability?

The question handled in this chapter is one which resists clear, empirical "yes" or "no" answers. There exist no objective and dependable measures of acoustic structuring ability, which could be used as validity criteria. All one can do is to construct the test so that its content validity is maximized, and to collect empirical data which clarify different sides of the problem.

The most obvious and probable dangers in this area are the possibilities that the test will measure either absolute, sensory capacities, or rote memory. In the first case, persons who are able to hear small differences in pitch, length, intensity, or timbre would succeed better in the test. Similarly, if the test measured rote memory, persons who can memorize the sound series without structuring them, would have an advantage over others.

There is very little empirical evidence to directly show that sensory capacities are not measured. Usually there have been no practical possibilities to add a sensory discriminating test to the measures used. Thus, this part of the validity must be expressed mainly in terms of content validity. To ensure the content validity in this respect, the structure-forming differences in pitch, length, and intensity have been made so large that they must be clear to a great majority of the subjects (Karma 1975,1, 1978,2). The factor analyses (Karma 1978) serve as modest empirical evidence that sensory capacities are not measured. If the abilities to differentiate sounds according to pitch, length, or intensity were distinguishable from each other, and if the test measured them, these structure-forming variables should have an impact on the factor structures of the different versions of the test. No such factors have emerged, however. Also, some subjects, reported by their music teachers to have difficulties in sensory differentiation, have gained exellent scores in the structuring test.

Showing empirically that memory is or is not measured is often a complicated task. It is the writer's opinion that logical errors are usual in research and test construction in this area. The concept "musical memory" has already been critisized earlier in this work (Karma 1973, 7, 1976, 7). The mere fact that something is memorized by someone and not memorized by someone else does not imply that memory has been the main operating factor. The fact that a test

contains items where the subjects must memorize something does not justify calling the test a memory test. The discriminating factor may as well have been the subjects' ability to perceive meaning in the material. This can be elucidated by an exaggerated example: let us suppose that there is a subject group consisting of native speakers of a language and persons to whom this language is unknown or only partly familiar. If the subjects were then given sentences in this language and instructed to memorize them, the native speakers would almost certainly be better in the task. One would not, however, draw the conclusion that they have the better memory but, of course, that they remembered the sentences better because they understood them.

Musical tasks may be "foreign language" to an unmusical person and thus difficult to remember. In linguistic connections this phenomenon has been extensively studied. "(In Organization Theory) ... it is argued that the manner in which information is encoded in the memory store is what determines what will be remembered ... in general, when subjects are presented with a well-organized passage (sentences organized by concept name or concept attribute), free recall of facts is higher than it is when the sentences are presented in a random order". (Shimmerlik 1978, 104, 107).

The regression analyses (Karma 1978) support strongly the view that the acoustic structuring test is sufficiently free from the effects of memory. In these analyses, item difficulty was predicted with some other properties of the items. All the predictors having something to do with the amount of material or the number of units to be remembered - the length of a subgroup, amount of different tones, amount of subgroups - were practically useless as predictors. If memory were measured, item difficulty would probably increase with the amount of material one has to remember.

The two best predictors in the regression analyses, amount of bits and "no"- item, may be considered measures of the ability to form and use expectations. The amount of bits increases with the amount of possible beginning-points of the subgroups; the increase in the number of expectations which are not filled makes the item more difficult. In a "no"-item the last group of sounds is not a repetition of the subgroups in the beginning. Such an item is very difficult if one has not formed an expectation about the structure of the last group. Thus, persons who do not form expectations or are unable to change them according to the situation get lower scores in the test.

Expectations cannot be based on random material or rote memory. Some kind of structure must be involved. Only the perception of an idea, meaning, or sequence can form a reasonable basis for expecting what will follow. To sum up this reasoning: persons who cannot perceive structures in the items are likely to get lower scores in the test.

2.2. Is acoustic structuring ability so clearly connected to musical behavior that it is reasonable to call it musical aptitude?

The empirical evidence as well as the content of the acoustic structuring test seem sufficient to justify the conclusion that the test really does measure the ability to structure acoustic material. Yet, this is only a technical aspect which supports the validity of the test but does not validate the theoretical considerations about the nature of musical aptitude. Knowing that acoustic structuring ability is measured does not justify saying that musical aptitude is measured. The problem in this phase is showing that structuring acoustic material is essentially a musical activity.

The context in which this question must be considered should be discussed first. It is very important to note that the problem is only partly empirical, the rest of it is a matter of agreement, reason, and practicality. We cannot "find" musical aptitude once and for all like we can find a mountain, new species of animal, or a chemical reaction. What we must do is to define an area of human behavior which is narrow and homogenous enough (to justify calling it one concept or factor) and wide enough (to cover essential parts of musical behavior and justify reasonably calling it "musical aptitude"). The definition should also be efficient and ease thinking and communication in the area to the greatest extent possible. What is "narrow, homogenous, or wide enough" as well as which are "essential parts of musical behavior", is to be decided by the researcher; only when these decisions have been made, does the problem become an empirical one. Even when the empirical correlations are available there is room for subjective judgement, the correlations cannot make decisions for the researcher but only help him in doing so.

According to the experience of the present writer, the most obvious and probable danger in this phase is that the way the structures are composed and the way the test is given make the results more or less measures of intelligence instead of musical aptitude. This does not mean that there should not be any correlation between the test results and intelligence. The most common view of the researchers in the area is that there is a low positive relation between musical ability and intelligence (Shuter 1964, 227, 308, Sergeant - Thatcer 1974, Phillips 1976). This relation is mainly caused by the covariation between musical ability and intelligence on <u>low</u> intelligence levels (Zenatti 1975). The most reasonable result we can expect from a music test is, then, that it correlates <u>more</u> with musical criteria than with intelligence.

Because the main interest has been focused on the relations between structuring ability on the one hand and verbal and spatial abilities on the other, no tests which could be called measures of general intelligence have been used. Probably satisfactory estimates of this (already in itself vague) concept can be attained by using the ranges and central tendencies of the different intelligence tests as guidelines. The correlations between the different versions of the acoustic structuring test and verbal or spatial tests have varied between -.09 and .47 (Karma 1978, 11). Version D of the acoustic structuring test was used with a wide battery of intelligence tests; the correlations ranged from .12 to .42 typical figures being around .20 - .30.

One set of musical criteria available is formed by the entrance examinations arranged by the music institutes. These include playing a piece (if the applicant has any former training), singing a tune, and an imitating test where given intervals, rhythms, and melodies are to be reproduced. Correlations between the structuring test and the abovementioned tasks are available from five different years and samples (Karma 1978, 8). The different samples have roughly equal numbers of cases and variances of practically equal size. Thus, straight averages from these figures are used as estimates of the typical correlations. The following correlations are attained: structuring test/playing .236, structuring test/singing .102, and structuring test/imitating test .280. If Hotelling's t-test for correlating correlations (Guilford 1973, 167) is applied, it is seen that the correlation with singing differs significantly from the other two (the corresponding t-values are 3.84 and 5.58) while the difference between the correlations with playing and the imitating test is nonsignificant (t=1.27). These values are based on the following average correlations:

	1	2	3
1 Acoustic structuring test			
2 Playing	.236		
3 Singing	.102	.356	
4 Imitating test	.280	.332	.448

(N= approximately 1 000)

These figures do not give much information about the validity of the test. It correlates most highly with the imitating test which can be considered the best measure of aptitude of the three but, on the other hand, the correlation with playing is so close that the difference is not significant. It is only possible to say with relative certainty that the structuring test has a closer connection to the imitating test than to singing.

As a group, the abovementioned correlations are of the same size as the correlations between the structuring test and intelligence. In other words, these figures do not support the view that the structuring test does not measure intelligence. Yet, it is possible that the selection procedures of the institutes are not very reliable. The practical experience of the author supports this view although no empirical evidence is available. Intelligence tests, on the other hand, are usually the most reliable tests used within the behavioral sciences. It is likely that the reliabilities of the intelligence tests clearly exceed those of the tasks given to the applicants in the selection. If this were the case, the the correlations between the structuring test and the selection tasks would be more affected by "shrinkage" than the correlations with intelligence, i.e. the "true" coefficients between the musical tasks and the structuring test would be higher.

The version C of the acoustic structuring test has been given to subjects from six year olds to adults, although the ages of the most frequent cases have varied from nine to eleven years. This wide scale of ages gives us a possibility to compare the development of the scores with age. When the total of 876 subjects is divided into subgroups according to age, the following raw scores and their deviations are attained:

Table 1. Statistics from the material tested with the C-version of the acoustic structuring test, grouped by age. N = 876.

Age	Numerus	Mean	St. deviation
7	40	24.3	2.75
8	108	24.2	2.84
9	149	25.7	2.85
10	148	26.1	2.32
11	145	26.3	2.38
12	90	26.9	2.36
13	64	27.4	2.13
14	48	27.2	2.77
15	16	28.4	2.09
16	17	28.0	2.33
17 and over	51	27.3	2.14

The results of the six years old subjects have been omitted because they were too obviously affected by the ability to understand the instruction.

The increase with age in the scores is very small. In an average, seven years old subjects are capable of answering correctly 89% of the amount of correct answers of adults; seven years old and adults are about 1.5 standard deviations apart. This does not follow the typical pattern of

development in the scores of an intelligence test where the increase is usually much steeper. For instance, in the Wechsler Intelligence scale for Children, fifteen year old subjects solve approximately twice the amount of items that seven year old subjects are capable of solving; the distance is about 2.5 standard deviations (Wechsler 1949, 10, 35, 59). In Heinonen's factor test, the typical average for 14 year old subjects in the reasoning and verbal subtests is two to three times that of nine year old subjects; these averages are about 2 standard deviations apart. (Heinonen 1963)

These figures are, of course, approximate and difficult to make comparable with each other. They show a tendency, however, which suggests that intelligence is not an important factor in the scores of the acoustic structuring test.

In spite of this difficulty and inexactness it is interesting to compare the increase of scores in some widely known, standardized tests of musical ability to those of the acoustic structuring test developed in the present studies. The former seem to be closer to intelligence tests in this respect. For instance, in Wing's Standardised Tests of Musical Intelligence the increase from the scores of eight year old subjects to those of adults is about 100% and at least two standard deviations (Wing 1960). Bentley's Measures of Musical Abilities show very similar trends (Bentley 1977). It is difficult to say if this can be considered a validity criterion or not, but at least it serves as a specified problem for future study.

Tammisto (1975, personal communication) gave version C to 143 students of Helsinki School of Economics, an institute on university level. This group can safely be

considered a sample from intelligent, not musically selected adults. Their mean score was 22.8 points. This mean is significantly lower than that of seven year old applicants for the music institutes. The difference is obviously caused by the way the applicants have been musically selected even before the selection organized by the institutes. On average they are interested in learning music, they are supposed to be musically talented, and most of them have some previous music training. These data show clearly that selection on a musical basis has much more to do with the scores in the acoustic structuring test than intelligence or age within the range the test can be used. This result speaks strongly for the validity of the test and the theoretical considerations it has been based on.

It is difficult to get direct correlations between the structuring test and musical aptitude. Achievement scores are strongly affected by external properties, such as motivation, intelligence, experience etc; in several studies intelligence or academic achievement have been found to predict achievement in music studies more effectively than musical criteria (Hufstader 1974, Nallinmaa 1973, Webber 1976, Lahdes - Peltonen 1967). In many cases it is difficult to make teachers estimate aptitude instead of achievement; class teachers are usually unable to give reliable estimates of individual pupils in this respect. In the cases where estimates of aptitude are available, the pupils are usually so carefully selected that there is very little variance left. Where reasonable estimates have been available, the correlations between the structuring test and estimates of aptitude have been very satisfactory (.60 - .76). (Karma 1973, 17, 1975, 13).

If one wants to call the acoustic structuring ability "musical aptitude", the empirical evidence presented here does not make it unreasonable. Beyond this, the choice of terms is subjective and depends on the general approach chosen by the researcher. The present writer tends to see these properties at least close to synonymous.

2.3. How is acoustic material structured?

It is self evident that the question about the way the human mind structures acoustic material cannot be exhaustively answered here; a vast amount of study would be needed for a sufficiently valid and reliable answer to this question. The aim of this chapter is to point out some approaches which seem interesting and thus motivate future study. Only a few preliminary answers can be given here.

As Laske (1977) has pointed out, the problem is essentially in the relation between process and structure. When a piece of music, for instance, is in a static state, in a form of a recording, or memory store, it is a structure; when it is reproduced, encoded in memory, or recalled, a process is involved. It is obvious that the different forms in which the piece of music can exist must be isomorphic, that is, the corresponding elements can be shown in each form of the same piece be it in the form of process or structure, magnetic tape or memory store etc. The crucial problem lies in the transformation rules between process and structure, the ways in which a process is translated into a structure and vice versa. More accurately, the problem is in the transformation between the objective, external world and the human mind; there is nothing mysterious, for instance, in the way a record player transforms the material groove structure of the record into an acoustic process.

Within the terminology of the Information Theory, it can be said that the problem is that of scanning. Scanning is a process where a whole is reproduced by picking its elements one after another and placing them or their equivalents at the receiving end according to the order they were picked. A good example of an application of this principle is the television. A beam in the camera "wipes" the picture line by line collecting the information into a one-dimensional chain of signals. These are used in the receiver in the same order and corresponding places to reproduce the original picture.

When a visual stimulus is perceived, it is usually both seen as a whole and scanned element by element. The relative importance of these ways of perceiving depens on the size and complexity of the stimulus, the need to concentrate on the details or the whole, the experience of the perceiving person, etc. For instance, when we move in a familiar environment where there are no new and interesting details, we usually act on the basis of a general impression of the environment and little scanning is necessary. When, on the other hand, we want to investigate a detailed map or a drawing of a machine we must in addition to a general impression form the image of the whole by studying its details and relating the successive inputs to each other and the whole.

It is possible, although tedious, to form the idea of a whole by scanning only, without seeing the whole simultaneously at all. This situation can be produced by covering a picture with a sheet of paper with a hole in it. The paper can be moved on the picture into any direction but always so that only a small portion of the picture can be seen at a time. Instead of placing the details into the general view which can be seen simultaneously,

they must be related to the more or less defective image of the whole in the memory.

At least superficially, this process seems similar to that of listening to speech or music. If no written music or text is available, the whole exists only in the listener's mind where it is produced by relating successive inputs to each other and forming expectations according to them. On the other hand, there is an obvious difference: a picture can be scanned in any direction or sequence while speech and sounding music are received in an order fixed in advance by the sender. Even if the text or music is in written form it is normally necessary to read it in the direction fixed by the cultural tradition or the composer to get the correct idea of it.

Which are more important, the differences or the similarities? Is perceiving music more like listening to speech or looking at a picture? If the original object and its meaning are essentially time-bound, is it possible to scan the memory store of such an object in any other than the original direction? What does it mean that there is a "holistic" idea of a piece of music in somebody's mind; has the sequence of sounds been transformed into a "spatial" memory store? Is it easier to grasp the whole if a spatial analogy is used? Does the musically illiterate musician (for instance a folk music player) structure music in the same way as the trained professional who is used to spatial analogies of sound? These are some of the questions evoked by the present study. There are some answers to them in literature but mainly these problems seem to be open and thus potential starting-points for future study.

The question about sequential vs. simultaneous perceiving and remembering is close to the issue of hemispheric dominance and its effects on verbal vs. spatial tasks.

A wealth of research findings shows that if the variance of general intellectual ability is removed, verbal and spatial abilities tend to oppose each other rather than correlate positively. This division also seems to have a physiological correspondence in the hemispheres of the brain. (Scheid - Eccles 1975, Rennels 1976, Bannatyne 1971, Smith 1964, 54, Vernon 1961, 23, Honda 1978). This dimension can also be seen in the material where version D of the structuring test was factor-analyzed with several other tests (Karma 1978, 7). When the variables are ordered from the highest negative loading to the highest positive loading on the second factor of the unrotated principal axes solution, a clear verbal - spatial dimension is found. When compared to the straight correlations with verbal and spatial tests, the structuring test is a little more on the spatial side in this factor-analysis, but this can be attributed to the strong correlation with reasoning-type tests in the analysis.

Table 2. The acoustic structuring test, version D, with some ability tests. Second factor of an unrotated principal axes solution. Variables ordered according to the sizes and signs of the loadings. N = 172.

loading	variable
.485	square completion
.441	mirror test
.428	perception speed
.319	Raven's progressive matrices
.161	additions
.154	structuring test, version D
-.047	logical order of words
-.060	mathematical problems
-.078	opposites
-.105	word analogies
-.131	word groups
-.218	vocabulary (Lukima)
-.227	sentence completion
-.269	ordering letters to words
-.319	synonymes

The studies concerning hemispheric dominance usually place musical abilities into the right hemisphere and thus, at least superficially, relate them with spatial abilities. This must be understood as a tendency instead of a clear division, however. It is very probable that a clear location does not exist, but that both hemispheres and both verbal and spatial types of abilities are used. This is supported by empirical research where connections between acoustic and visual thinking and perceiving as well as between musical and verbal phenomena have been found. For instance, Lang and Ryba (1976) found that (visual) artists scored almost as high as musicians in acoustic tests. Kokkonen (1976) analyzed all those parts of Mozart´s piano sonatas which are in sonata form and noticed that their inner relations are surprisingly close to the sectio aurea which is so well known within the visual arts. On the other hand, Linde (1975) and Gabrielsson (1973) have found that there are evident connections between poetic and musical rhythm. Perney (1976) found correlations from .44 to .51 between musical and verbal tasks. Rushford-Murray (1977) presented attack and legato transients and steady states of instrument sounds dichotically to her subjects and came, among other things, to the conclusion that "evidence regarding certain analogies between music and speech have been shown to exist".

In the present series of studies the similarity between spatial and musical structuring was taken as the starting-point and acoustic structuring was expected to be more closely connected to spatial ability than to general intellectual ability. The latter was later changed to "verbal ability", however, because the verbal - spatial dimension seemed to appear relatively consistently in the literature and also showed itself in the material analyzed in the present study.

In the first two materials this hypothesis seemed to hold (Karma 1975) but disappeared later and, eventually, turned to the opposite direction, acoustic structuring correlating about zero with spatial tasks and approximately .40 with verbal tasks. Attempts to explain this change with sex, modifications in the acoustic structuring test, or spatial/verbal dominance were unsuccessful. It was concluded, then, that the cause was the amount of musical training and/or experience the subjects had. The first two subject groups were applicants for music training who as a rule already had previous training. The rest of the subjects handled in this connection were musically unselected comprehensive school pupils of whom just a few had any musical training other than the one that belongs to the normal curriculum during the first three or four school years.

The following conception about the relations between verbal, spatial, and musical information processing can be constructed on the basis of the empirical results handled above:

- The primary, "natural", way of processing acoustic material is similar to the one used in processing speech or uses partly the same neural functions. These may be both acquired by training and inherited. This view is in accordance with the one Suzuki (1969) presents. In his method the learning of language and the learning of music are seen as parallel phenomena. Accordingly, teaching is based on continuous listening to music, imitation, etc, and is started without written music.

- This tendency of untrained persons to analyze or perceive acoustic material "verbally" seems to be unrelated to the verbal/spatial dominance of the person. Thus, spatially talented persons do not use their full potential in acoustic structuring. An obvious corollary of this and the widely known fact that girls are better in verbal tasks, is that girls will be better in musical tasks in an unselected

sample. This phenomenon can be seen in the results of the present study (Karma 1978) and, for instance, in Perney's (1976).

- Musical training seems to increase a person's possibilities to use spatial analogies in processing acoustic material. This makes the difference in the levels of the performances of the verbal and spatial types of people disappear, but may not affect the different styles in processing musical material. There are some results which suggest sex differences in musical perceiving or thinking (Whellams 1973, Shuter-Dyson 1978); these might be caused by the "verbal" and "spatial" styles of data processing.

With the present material it is not possible to show empirically that the sex difference in the level of ability has disappeared with training. There is no clear sex difference in the success in music studies or the entrance examinations, but this can be attributed to the difference in motivation: boys and girls are not equally represented in the groups of applicants. The present writer feels that boys need more motivation before they apply and thus their proportion is smaller.

It is clear that these interpretations must be taken as preliminary only. A correlation between spatial or verbal ability and acoustic strusturing does not prove that those abilities are actually used in processing acoustic material. However, this interpretation leads to an interesting set of corollaries which should be validated by further study.

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